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The gaseous effluent is characterized as a fuel gas with a heating value of 300 BTU/ft.[3] This gas may be used as a supplemental fuel in a turbine to generate electric power or in a boiler to generate steam. Both alternatives would require use of a flare during unit downtime. Compressed storage of the gas is possible but would be very expensive due to the cost of the storage vessels. Economic liquefaction of the gas is not feasible since the major gas components are hydrogen and carbon monoxide, which have boiling points substantially below that of natural gas.

If the gasifier were not operating, an alternative source of gaseous fuel would be required to support on-site processes. The relatively short duration of the overall program and potential non-continuous operation of supporting facilities with the TOXIPLEX process complicate the use of the product gas for off-site applications. The cost of a turbine/generator may not be economical given the short mission time. Because sulfur, phosphorus, and halogens are potentially present in an agent feed (agent dependent), off-gas treatment for the removal of these inorganic components would be required as part of the off-gas treatment process.

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Since agent from ton containers will contain heavy metals, their ultimate fate when introduced into the gasifier must be determined. It had been expected that metals or ungasified components of neat agent fed to reactor, or processed agents, limestone or carbonaceous feed would be concentrated in the slag. However, tests performed at Columbia University [6] with toxic heavy metal compounds indicate the opposite: "A preponderant fraction of the metal and metal oxides introduced with the 1:2 coal/RDF pellets was carried over with the gaseous products; part was plated out on the upper, cooler portion of the refractory gasifier lining; part was trapped out with the condensed coal tars; and a negligible fraction was present in the fritted vitreous, silico-alumina slag." These results indicate the importance of determining the final dispensation solids contained within the organic feedstock, whether it be neat or treated agent such as hydrolysate.

For feedstocks containing primarily organic materials, the highly reducing environment of the gasifier precludes the formation of furans and dioxins as would be found in an incinerator during periods of operational upsets. This, coupled with the high destruction efficiency found for tested organics and the low potential inventory of the gasifier, makes the gasifier a suitable treatment for chemical warfare agent if the issues of product gas volume and mass of solid waste is acceptable. The gasifier, as a chemical warfare agent treatment option, appears to be potentially viable compared with existing process options used or contemplated today for new facilities.

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5.1 Permitting History

There is extensive permitting history of the process for use as a gasifier. However, use of the process for destruction of hazardous materials only includes permitting as research and demonstration facilities.

**6. Schedule**

Prior to full-scale implementation a pilot scale facility would need to be built and tested, first with surrogate feed and then with agent. Dynecology expects this to take at least 3 to 6 months. The schedule for implementation of a full-scale design would be heavily dependent on permitting requirements, which are expected to be less than those required for permitting an incinerator.

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**7. Cost**

Capital cost estimates were not contained within the information reviewed from Dynecology. For a 22,000 pound per day agent destruction facility, Dynecology reports a cost for operation of $1500 to 2000 per ton or about $7,500 to $10,00 per 10,000 pounds of chemical agents destroyed [1]. Supporting information was not provided.

A detailed cost analysis comparing a facility using the TOXIPLEX technology versus existing technologies, such as incinerators was not provided within the material reviewed. Adjustment values for potential improved process control, lower inventory-at-risk, and higher destruction efficiency have not been determined and are required in order to assess the magnitude of potential benefits achieved by using this technology.

**8. Implementation at Existing Chemical Demilitarization Incineration Facilities**

Dynecology proposed [1] that TOXIPLEX replace the liquid agent incinerator at the existing Tooele, Utah site, but did not provide any site specific implementation information including interface requirements for existing systems, demonstration and test plans, construction schedules, waste handling, permitting requirements and schedules, etc.

The Tooele site includes four incinerator systems, each with a specific function of treating metal parts, explosives and propellants, liquid agent or dunnage. The TOXIPLEX system is applicable to only treating liquid agent and would only replace the existing liquid agent incinerator. The other incinerator systems would still remain in operation.

For an existing agent treatment facility utilizing incineration, cost factors such as providing new interfacing or support utilities such as material handing of coke pellets, off-gas treatment, and effluent flaring would additionally have to be addressed. Although no analysis has been

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performed, it would appear unlikely that a cost-benefit approach could be used to justify a process change utilizing this technology.

The hazards analysis [7] for the Tooele liquid incinerator system indicates that if failures were to occur, the agent feed piping system failures are most likely. Appropriate control design, however, could be employed to limit the release of agent from a feed line failure. Since the dominant failure modes and risks do not involve failure of the incinerator system, replacement of the incinerator with the TOXIPLEX system would not be expected to lead to an overall improvement in public safety.

**9. Conclusions**

- The TOXIPLEX technology offers the potential for high agent destruction efficiency. Destruction efficiencies of 6 and 7 nines were achieved when treating hexachlorabenzene and PCBs and destruction efficiencies for chemical agents would be expected to be as good.
- The solid waste (slag) quantity produced requires disposal, since use of the waste for other purposes is unlikely. However, since the solid waste produced is a function of the ash content of the fuel, it can be virtually eliminated by using a low ash petroleum coke or a refractory metal oxide such as zirconia instead of ordinary coke as the incandescent contact surface.
- Use of the product as a fuel needs to be identified, otherwise it would have to be flared. Alternatively, it could be used as a supplemental fuel in the event that (in order to substantially reduce the production of solid waste or slag) a refractory metal oxide is substituted for coke as the incandescent contact surface.
- The thermal inertia of the gasifier would allow variations in feeds without compromising destruction efficiency.
- The TOXIPLEX process would most likely achieve high operability and reliability given the maturity of the technology and the long operating history of commercial-size slagging gasifier plants.
- Due to the rapid destruction rate (50 to 100 milliseconds), the inventory of toxic materials available for release from the gasifier during an abnormal or accidental release condition is extremely low. The low inventory minimizes both the on-site and off-site consequences for reaction vessel failure or leakage. The safety of existing support systems at Tooele may limit the safety benefits of the TOXIPLEX process. Therefore, the overall benefit for replacement of the agent incinerator at Tooele, with the TOXIPLEX process, appears to be marginal.

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- For new facilities treating chemical warfare agents, this technology may be competitive with existing technologies and provide potential advantages in destruction capability and lower inventory-at-risk.